NCI ALLIANCE FOR NANOTECHNOLOGY IN CANCER
CENTERS OF CANCER NANOTECHNOLOGY EXCELLENCE

FACT SHEET

FEBRUARY 2006

For the past seven years, the National Cancer Institute (NCI) has taken the lead in integrating nanotechnology into biomedical research through a variety of programs. The results of these efforts have demonstrated clearly that combining development efforts in nanotechnology and cancer research will have a profound, transformative effect on how we prevent, diagnose, and treat cancer.

To capitalize on the promise of nanotechnology in cancer, the NCI launched the Alliance for Nanotechnology in Cancer in September 2004. The Alliance, built on a strong foundation of science and scientific accomplishment, is a comprehensive, systematized initiative encompassing the public and private sectors. It is designed to accelerate the application of nanotechnology to the major challenges in clinical oncology and basic cancer research.

The Alliance has four major components:

- **Centers of Cancer Nanotechnology Excellence (CCNEs)** will fund eight hubs over 5 years to develop and apply nanotechnology and nanoscience solutions to the diagnosis and treatment of cancer. These awards were announced on October 3, 2005. Funding for the first year of this program will total $26.3 million.
- **Cancer Nanotechnology Platform Partnerships** are tightly focused programs designed to develop the technologies to underpin new products in six key programmatic areas: molecular imaging and early detection, in vivo imaging, reporters of efficacy (e.g., real-time assessment of treatment), multifunctional therapeutics, prevention and control, and research enablers (opening new pathways for research). These 12, 5-year R01 awards will be announced in October 2005. The first-year funding on these awards will total $7 million.
- **The Nanotechnology Characterization Laboratory (NCL)**, (http://ncl.cancer.gov), established at NCI's Frederick, Maryland, facility in 2004, performs analytical tests to guide the research community; support regulatory decisions; and help identify and monitor environmental, health, and safety ramifications of nanotechnology applications. The NCL recently completed its first year of operation and is actively characterizing nanoparticles for academic and commercial researchers through a rigorous set of analytical protocols. The NCL works closely with the National Institute of Standards and Technology (NIST) and the U.S. Food and Drug Administration (FDA).
- **Multidisciplinary research training and team development** is a major focus of the Alliance because the application of nanotechnology to cancer challenges requires teams of scientists with knowledge and understanding that crosses disciplines, particularly in the biological and physical sciences. The Alliance will support training and career development initiatives to establish integrated teams of cancer researchers. The Alliance will provide this training support through existing and new mechanisms. For example, the Alliance will provide training funds through the NIH National Research Service Awards

for Senior Fellows and the NIH National Research Service Awards for Postdoctoral Fellows. In addition, in September 2005, through the NCI's collaboration with the National Science Foundation (NSF), $12.8 million in new grants were awarded to four institutions over the next 5 years for U.S. science and engineering doctoral students to focus on interdisciplinary nanoscience and technology research with applications to cancer (see NCI-NSF press release, September 21, 2005).

Centers of Cancer Nanotechnology Excellence (CCNEs)

The newly established CCNEs will serve as hubs of the NCI Alliance for Nanotechnology in Cancer to develop and apply nanotechnology and nanoscience solutions to the diagnosis and treatment of cancer. As hubs of the Alliance, the goals of the CCNEs are to design and test nanomaterials and nanodevices and to translate their use into clinical research, resulting ultimately in the introduction of new diagnostic tools and treatment techniques to combat cancer. The CCNEs will bridge gaps in the development pipeline from materials discovery to technology testing in clinical trials.

In making the Centers of Cancer Nanotechnology Excellence awards, the NCI is recognizing the scientific merit and clinical promise of the research projects, as well as the strength of the multidisciplinary teams, which include researchers from the public and private sectors that have come together to participate in these Alliance programs. These highly integrated centers will engage in directed, product-focused research that will aim to translate cutting-edge science and technology into the next generation of diagnostic and therapeutic tools that will ultimately benefit cancer patients.

Nanotechnology represents a wide range of scientific endeavors and tools, and the CCNE awards reflect that broad cross-section of technologies and disciplines being applied by teams distributed geographically across the United States, with applications across the entire spectrum of cancers and cancer patients. The selected CCNEs will engage in a range of near-term projects that are approaching clinical use, as well as cutting-edge projects that will have an exceptionally significant impact on clinical oncology if they are brought to fruition.

By balancing structured directives with investigator-initiated research, these centers will bring together the interdisciplinary teams from existing NCI resources and will provide the infrastructure necessary to develop and translate nanotechnology advances to the clinic. The CCNE network will focus unswervingly on developing the technology that is so necessary to accelerate the pace of product approval, commercialization, and delivery to cancer patients.

Each of the eight CCNEs is linked to a regional, NCI-funded Comprehensive Cancer Center and one or more Specialized Programs of Research Excellence (SPOREs). In addition, each of the eight CCNEs includes biomedical researchers and investigators from engineering and physical science departments. All eight CCNEs also have advanced biocomputing capabilities and have forged partnerships with colleagues in the not-for-profit community and/or private sector to accelerate work related to the nanotechnologies they are working to develop.

Carolina Center of Cancer Nanotechnology Excellence

The major thrust of this center, a collaboration between the University of North Carolina and the Lineberger Comprehensive Cancer Center, is to design and fabricate novel and innovative, multifunctional nanodevices and then test their *in vivo* performance using sophisticated mouse models of human cancer. In addition, this center will use breakthrough nanodevice fabrication technology to develop nanoscale tools for research and detection applications. In addition to general oncology applications, this CCNE will focus on leukemia; lymphoma; myeloma; and brain, breast, colon, and lung cancers.

The deliverables expected from this CCNE include:

- Smart nanoparticles for cancer therapy and imaging
- Carbon nanotube x-ray devices for *in vivo* cancer detection and treatment
- Targeted magnetic nanoparticles for brain tumor imaging and therapy
- Chemically patterned nanoscale surfaces for capturing tumor cells
- Nanofluidic devices for rapid, single-cell analysis of tumor cell signaling and migration

Statement from principal investigator Rudolph Juliano, Ph.D., University of North Carolina

"We are delighted that the NCI is giving us this exciting opportunity to help bring nanotechnology to bear on cancer research, diagnosis, and treatment. Our program grows out of the very collegial environment at UNC that has allowed our physical scientists in the College of Arts and Sciences to interact productively with cancer researchers at the Lineberger Comprehensive Cancer Center and with investigators in our Medical School academic departments, particularly the Department of Pharmacology. We look forward to focusing all of our manifold biomedical science and physical science resources on key issues in cancer under the aegis of the Carolina Center of Cancer Nanotechnology Excellence. We are confident that our nanotechnology strategies and technologies will rapidly result in new insights into cancer biology and significant improvements in the quality of life for individuals with cancer."

Rudolph Juliano, Ph.D.
Professor, Department of Pharmacology, School of Medicine
University of North Carolina, Chapel Hill

Center for Cancer Nanotechnology Excellence Focused on Therapy Response

This collaborative effort brings together scientists and physicians from Stanford University, the University of California, Los Angeles (UCLA), Cedars Sinai Medical Center, Fred Hutchinson Cancer Research Center, University of Texas at Austin, Intel, and General Electric. This team will focus on using nanotechnology to advance both *ex vivo*, i.e., laboratory-based, diagnostics and *in vivo* molecular imaging, and that the combined use of these nanotechnology-enabled diagnostic tools can markedly impact future cancer patient management. In addition to general oncology applications, this CCNE will focus in particular on prostate cancer.

Specific project goals include the development of:

- Nanotube-nanowire and nanoscale magnetic devices for detecting rare proteins
- Multiplexed protein phosphorylation detection device based on Raman sensors
- Devices for profiling proteins on cell surfaces
- Targeted quantum dots for molecular imaging in living subjects

Statement from principal investigator Sanjiv Sam Gambhir, M.D., Ph.D., Stanford University

"It has become clear to everyone in the cancer community that the ability to monitor cancer therapies in their earliest stages are a critical opportunity – almost within our grasp – that will transform clinical outcomes for patients. At our Center, we will gather some of the finest minds in the academic and private sectors, from Stanford, UCLA, Cedars Sinai, Fred Hutchinson, University of Texas, Intel and General Electric, to use nanotechnology in the development of a new generation of management tools to fight some of the deadliest cancers. These technologies will also eventually impact the early detection of cancer. I cannot think of any comparable research effort as large in its magnitude, as potentially positive in its near-term impact, or as focused in its intent as this collaboration. We are grateful to the National Cancer Institute as we set forth on this endeavor by joining the Alliance for Nanotechnology in Cancer with tremendous enthusiasm and commitment."

Sanjiv Sam Gambhir, M.D., Ph.D.
Director, Molecular Imaging Program at Stanford
Head, Nuclear Medicine
Professor, Departments of Radiology & Bioengineering
Bio-X Program
Stanford University

Center of Nanotechnology for Treatment, Understanding, and Monitoring of Cancer (NANO-TUMOR)

NANO-TUMOR is a collaborative effort involving the University of California, San Diego (UCSD), Moores UCSD Cancer Center, UC-Santa Barbara, UC-Riverside, the Burnham Institute, market research organization NanoBioNexus, and five corporate partners: General Electric Company, Honeywell, Nanogen, Irvine Sensors Corporation, and Enterprise Partners Venture Capital.

The focus of this team will be to develop smart multifunctional nanoplatforms capable of targeting tumors and delivering large payloads of therapeutics and nanosensors to the tumor environment. In addition to general oncology applications, this CCNE will focus on breast cancer and leukemia.

Specific projects of this CCNE include development of:

- Tumor-homing peptide-nanoparticle complexes
- Porous nanoparticles for drug and sensor delivery
- Computational methods for monitoring tumor progression and response using data from nanoparticle-delivered sensors
- Enzyme-sensitive nanoparticle coatings to increase tumor-targeting capabilities of smart nanoparticle platforms

Statement from principal investigator Sadik Esener, Ph.D., University of California, San Diego

"Nanotechnology allows us to much more specifically and accurately deliver an array of promising new treatments to the exact positions in the body where they are needed. Nanotechnology will also enable doctors to get more rapid noninvasive feedback on the effectiveness of treatment, and when biopsies are needed, these approaches will require much smaller tissue samples for analysis in the laboratory."

Sadik Esener, Ph.D.
Professor of Electrical and Computer Engineering at the UCSD Jacobs School of Engineering
University of California, San Diego

Emory-Georgia Tech Nanotechnology Center for Personalized and Predictive Oncology

This collaboration between Emory University's Winship Cancer Institute, the Georgia Institute of Technology, and Nanoplex Technologies will focus on the development of bioconjugated nanoparticles for cancer molecular imaging, molecular profiling, and personalized cancer therapy. In addition to general oncology applications, this CCNE will focus on breast, prostate, renal, colon, and bone cancers.

In particular, this CCNE, together with partners at the American Cancer Society and the U.S. Centers for Disease Control and Prevention (CDC) and with additional funding from the Georgia Research Alliance and Georgia Cancer Coalition, will tackle projects that include the development of:

- Tumor-targeted infrared quantum dots with both optical and magnetic imaging capabilities
- Smart nanoparticle probes for intracellular drug delivery and gene expression imaging
- Antibody-conjugated quantum dots to detect and quantify human breast cancer biomarkers
- Nanoparticle tags for tracking multiple biomarkers in biological specimens using surface-enhanced Raman spectroscopy
- Nanoparticles for delivering therapeutics directly to bone metastases

Principal investigators: Shuming Nie, Ph.D., Emory University and Georgia Institute of Technology, and Jonathan Simons, M.D., Emory University

Statement from principal investigator Shuming Nie, Ph.D.

"These CCNE awards represent a milestone and a "sea change" in developing cutting-edge nanotechnology for translational cancer research. A unique feature of our cancer nanotechnology center at Emory University and the Georgia Institute of Technology is that it is embedded in a new model of a developing comprehensive cancer center, the Winship Cancer Institute (WCI). Our overarching scientific focus is to accelerate the development of bioconjugated nanoparticles linked with biomolecular signatures for tumor imaging, molecular profiling, targeted therapeutics in medical oncology, and early detection, with a particular focus on human prostate and breast cancers."

Shuming Nie, Ph.D.
Wallace H. Coulter Distinguished Chair
Professor of Biomedical Engineering, Chemistry, Hematology and Oncology
Associate Director, Winship Cancer Institute
Emory University and Georgia Institute of Technology

Statement from principal investigator Jonathan W. Simons, M.D.

"This grant is a tremendously important step forward in collaborative cancer research. At the Winship Cancer Institute and Georgia Tech, we are working together to create bioengineering technologies that will lift the entire field of cancer research and cancer care. This collaboration is strengthened by the vision and involvement of the National Cancer Institute and the State of Georgia through the Georgia Cancer Coalition and the Georgia Research Alliance which have worked tirelessly to foster a thriving collaborative research environment."

Jonathan W. Simons, M.D.
Director of the Winship Cancer Institute
Emory University

MIT-Harvard Center of Cancer Nanotechnology Excellence

Organized and administered by the Massachusetts Institute of Technology (MIT) Center for Cancer Research, this center will be a collaboration among MIT, Harvard University, Harvard Medical School, Massachusetts General Hospital, and Brigham and Women's Hospital. It will focus on developing a diversified portfolio of nanoscale devices for targeted delivery of cancer therapies, diagnostics, non-invasive imaging, and molecular sensing. In addition to general oncology applications, this CCNE will focus on prostate, brain, lung, ovarian, and colon cancers.

Examples of projects that this CCNE will undertake include the development of:

- Targeted nanoparticles for treating prostate cancer
- Polymer nanoparticles and quantum dots for siRNA delivery
- Next-generation magnetic nanoparticles for multimodal, non-invasive tumor imaging

- Implantable, biodegradable microelectromechanical systems (MEMS), also known as lab-on-a-chip devices, for *in vivo* molecular sensing of tumor-associated biomolecules
- Low-toxicity nanocrystal quantum dots for biomedical sensing

In addition to drawing on the scientific and technological expertise of its investigators, this CCNE will use available facilities for toxicology testing and the extensive mouse models of cancer collection at the collaborating institutions.

Principal investigators: Robert Langer, Ph.D., Massachusetts Institute of Technology, and Ralph Weissleder, M.D., Ph.D., Harvard University, Massachusetts General Hospital

Statement from principal investigator Robert Langer, Ph.D.

"This is a great opportunity for MIT and Harvard to pursue interdisciplinary science at the intersection of cancer research and nanotechnology, and hopefully to do some real good for patients."

Robert Langer, Ph.D.
Germeshausen Professor of Chemical & Biomedical Engineering
Massachusetts Institute of Technology

Statement from principal investigator Ralph Weissleder, M.D., Ph.D.

"The MIT-Harvard CCNE will provide an essential infrastructure to fast-forward the development of novel nanomaterials and rapidly apply them to cancer problems."

Ralph Weissleder, M.D., Ph.D.
Professor, Harvard Medical School; Director Center for Molecular Imaging Research
Harvard University, Massachusetts General Hospital

Nanomaterials for Cancer Diagnostics and Therapeutics

This CCNE represents a strongly integrated partnership between Northwestern University's International Institute for Nanotechnology and the Robert H. Lurie Comprehensive Cancer Center of Northwestern University. This highly multidisciplinary group of nano-scientists, engineers, cancer biologist, and clinicians will use nanotechnology to develop a range of tools with use in clinical oncology using a variety of nanoscale materials and devices. In addition to general oncology applications, this CCNE will focus on ovarian, colon, breast, and prostate cancers and lymphoma.

The six research projects of this CCNE aim to develop:

- Bio-barcodes to detect ovarian cancer markers
- A new class of drugs that will inhibit or reduce metastasis
- Bioactivated nanoprobes for molecular imaging of cancer

- Targeted, multifunctional nanoparticles for drug and radiopharmaceutical delivery
- Nanocomposites for imaging prostate cancer cells and treatment of advanced prostate cancer
- Self-assembling supramolecular nanostructures that deliver chemotherapy agents directly to breast and other cancer tumors

Statement from principal investigator Chad Mirkin, Ph.D., Northwestern University

"This new center brings together two of Northwestern's strongest research entities with the shared goal of using advances in nanoscience and technology to address one of the world's most deadly and debilitating classes of diseases. Center work will lead to new ways to detect cancer at much earlier stages, powerful imaging tools, and therapies much more efficient than conventional methods."

Chad Mirkin, Ph.D.
George B. Rathman Professor of Chemistry
Professor of Materials Science & Engineering, and Medicine
Director of the International Institute for Nanotechnology
Northwestern University

Nanosystems Biology Cancer Center (NSBCC)

The NSBCC establishes a collaborative team comprising investigators from the California Institute of Technology, the Institute for Systems Biology, UCLA's Geffen School of Medicine, and the Jonsson Comprehensive Cancer Center. The focus of this effort will be to develop and validate tools for the early detection and stratification of cancer through rapid and quantitative measurements of panels of serum and tissue-based biomarkers, and then to use those tools to evaluate the efficacy of various cancer therapies. In addition to general oncology applications, this CCNE will focus on prostate and ovarian cancers, glioblastoma and melanoma. During the course of the projects that this CCNE will conduct, investigators will develop:

- Molecular imaging and targeting probes using "click" chemistry
- Integrated Nanoelectronics/microfluidics chips for multi-parameter diagnostic and measurement tools capable of detecting and quantifying trace biomolecules involved in cancer
- Chip-based tools for isolating rare circulating immune system cells as a means of evaluating the efficacy of immune-based cancer therapies
- Identification of organ-specific serum-based biomarkers for the detection and stratification of various cancers through blood analysis
- Methods for manufacturing low-cost nanofluidic diagnostic chip-based devices

Statement from principal investigator James Heath, Ph.D., California Institute of Technology

"The clinical treatment of cancer will undergo profound change over the next 10 to 15 years. This change will be catalyzed by a systems biology approach towards understanding the disease, and by microfluidics and nanotechnologies that can translate that approach into clinically useful tools. This will allow for an early and informative diagnosis of cancer through in vitro diagnostics and in vivo molecular imaging, and it will allow for the monitoring of the positive and adverse responses to therapy. The goal of the NSBCC is to serve as the agent of that change by developing the core technologies for achieving this vision, and for catalyzing the commercialization of those technologies. The combination of nanotechnologies from Caltech, proteomics, genomics, and computational biology from the Institute for Systems Biology, and terrific cancer biology and clinical cancer programs from UCLA and its Jonsson Cancer Center will provide us with tremendous leverage for realizing this vision."

James Heath, Ph.D.
Gilloon Professor and Professor of Chemistry
California Institute of Technology

The Siteman Center of Cancer Nanotechnology Excellence

This collaboration between Washington University in St. Louis; the University of Illinois, Urbana-Champaign; the Alvin Siteman Cancer Center; and several private sector start-up companies including, Kereos and Stereotaxis, and multinational companies such as Philips Medical Systems, will concentrate on developing nanoparticles for *in vivo* imaging and drug delivery, and new imaging and characterization tools for characterizing the interactions of nanoscale materials with living cells. In addition to general oncology applications, this CCNE will focus on breast cancer and melanoma.

Projects conducted by this center's collaborators will include the development of:

- Magnetic nanoparticles that can target multiple tumors for early detection and therapy of cancer
- Nanoparticle-based contrast agent for ultrasound imaging and therapy of tumors
- Bioinformatics tools to create a database for modeling the behavior of targeted nanoparticles in the body
- Novel nanoscale sensors for rapidly screening potential anticancer drugs in single cells

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Statement from principal investigator Samuel Wickline, M.D., Washington University

"Translational medical research in the future demands more than just academic basic science and clinical research. Experience in drug development, preclinical testing, and clinical trials has become an upfront necessity. The CCNE program recognizes this paradigm shift in medical research by fostering interdisciplinary and multidimensional collaborations that will solve cancer problems over the next decade."

Samuel A. Wickline, M.D.
Professor of Medicine, Biomedical Engineering, Physics, and Cellular Biology
Washington University

About the NCI Alliance for Nanotechnology in Cancer

To help meet the goal of eliminating suffering and death due to cancer, the National Cancer Institute is engaged in efforts to harness the power of nanotechnology to change the way we diagnose, treat, and prevent cancer. The NCI Alliance for Nanotechnology in Cancer is a comprehensive, systematized initiative encompassing the public and private sectors, designed to accelerate the application of the best capabilities of nanotechnology to cancer. Among the Alliance goals are to develop research tools to identify new biological targets, as well as agents to monitor predictive molecular changes in order to prevent precancerous cells from becoming malignant. In addition, the Alliance promotes the development of better diagnostics and treatment regimens using nanotechnology to target specific cancer cells amongst healthy cells.

The Alliance for Nanotechnology in Cancer is an integrated, milestone driven, and product-oriented program with targeted objectives and goals, initiated to capitalize on opportunities to create the tools that both clinicians and cancer researchers need now to eliminate suffering and death due to cancer. By working to fulfill this core mission of the NCI, the Alliance offers training and career development mechanisms to direct talent to this area as quickly as possible and to incentivize cross-disciplinary research through training the scientific community. For more information on the NCI Alliance for Nanotechnology in Cancer, please visit http://nano.cancer.gov.

About the National Cancer Institute

The National Cancer Institute (NCI) is a component of the National Institutes of Health (NIH), one of eight agencies that compose the Public Health Service (PHS) in the Department of Health and Human Services (DHHS). The NCI, established under the National Cancer Act of 1937, is the Federal Government's principal agency for cancer research and training. For more information about the NCI, please visit http://www.cancer.gov.

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